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## KONSER KARYA ILMIAH NASIONAL 2019

“Kesiapan Sumber Daya Manusia Pertanian Menghadapi Revolusi Industri 4.0”

Selasa, 2 Juli 2019 | Fakultas Pertanian & Bisnis UKSW

## WATERLOGGING CONSTRAINS ON PLANT GROWTH AND PLANT BIOMASS OF BARLEY, CORN, CANOLA AND FABA BEAN

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### Abstract

Waterlogging promotes roots stress and contributes to inhibit the plant growth. The aim of this research was to investigate the plant growth and plant biomass on barley, corn, canola and faba bean under waterlogging condition. On 20 days after sowing, the plants were flooded until the soil surface. The flooded treatment was applied until 43 days after sowing, then, the plants was harvested. To compare the normal soil condition, the control treatment with no flooded condition was applied with the same plants. The results show that waterlogging is a constraint for barley, corn and canola with decreasing of plant growth and plant biomass under waterlogging treatment. Then, for faba bean as a legume plant that gives tolerant reaction under waterlogging condition. The root form of faba bean contributes on adaptation under saturated water in the root zone by avoiding oxygen un-available

**Key words:** waterlogging, barley, canola, corn, faba bean

### INTRODUCTION

Water surplus in the root zone that promotes anaerobic conditions is called waterlogging (Moore, 2001). This condition develops abiotic stress on roots, then, contributes to inhibit the plant growth and development. In the early plant growth period, waterlogging promotes delay on plant growing period and it also contributes to yield losses especially in the wet years (Moore, 2001).

Climate characteristic such as temperature and rainfall, soil characteristic and external drainage including landform play a role in the waterlogging susceptibility. The region that has  $\geq 400$  mm rainfall gain potential yield and pasture loss up to 80% due to waterlogging (McFarlane & Williamson, 2002). Low landform paddock facing waterlogging due to the potential accumulation of water in the low landform. Then, it contributes to inhibit the plant growth that is grown in the low landform area. Moreover, McFarlane and

Williamson (2002) state that waterlogging will not commence in the landform with 5% slope, however, it will be a significant waterlogging if the slope of landform is 0.8%. Clay and sand soil texture also contributes on the waterlogging in the paddock. Clay with extremely fine

particles has an ability to hold the water, it is the most susceptible soil texture facing the waterlogging. In contrast, the sand with coarse particles is the less susceptible to waterlogging. Soil with dominant in sand particles will easily drain the water. Almost two-thirds agricultural paddock in Southwest region of Western Australia has sandy loam on the top soils and sandy clay on the subsoils. This contrast soil texture causes the soil to more susceptible on the waterlogging especially in the winter with high rainfall (Moore, 2001).

Some plants response the waterlogging as a constraint because saturated water in the root zone inhibits the gas exchange, then, oxygen supply is inadequate (Ashraf,





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2012). Tolerant plant response the waterlogging in the adaptation mechanism by lowering the respiration rates or aerenchyma form. The tolerances mechanism of waterlogging is depended on the plant species.

The aim of this research was therefore to the plant growth and plant biomass on barley, corn, canola and faba bean under waterlogging condition. It was hypothesized that plant species shows the different plant growth. Then, it also expected that cereal crop and oilseeds plant shows the negative impact on plant growth under waterlogging condition compares to legume plant.

## RESEARCH METHODE

### *Plant materials*

The experiment was conducted in the glasshouse using two cereal crops, one oilseeds crop and one legume species. The cereals crop plants were *Hordeum vulgare* (Barley), *Zea mays* (Corn); oilseeds crop was *Brassica napus* (canola) and *Vicia vaba* (Faba bean) as legume plant were used to explore the waterlogging experiment. Starting with 6 seeds in each pot and thinned after 2 weeks to becomes 4 plants per pot for barley and corn and becomes 3 plants per pot for canola and faba bean. Plants showing date was on 24 July 2017.

A diameter of the pot is 16 cm with height is 17 cm. The Curtin University standard potting mix was used to grow the plant. Application of fertilizer was on seeding stages using complete basal fertilizer (Nitrophonska) with the rate at 5 gram/plot.

### *Waterlogging treatments*

The waterlogging treatment was imposed by placing the pots into the trays that filled

with water until the soil surface was flooded by water. Control as a non-waterlogging treatment was used to compare the plant growth. The waterlogging procedure starts on 14 August 2017 at 20 days after showing.

### *Sampling and measurements*

All data were collected at the same time (plant height, fresh shoot and root). The plant was harvested in the steam extension stage on 43 days after showing. Plant height was measured directly using a ruler. The fresh biomass was distinguished between fresh root and fresh shoot. The roots were cleaned with the water to wash the soil. Fresh root and shoot data were recorded by weighing the biomass to the scale. Dry matter of root and shoot was distinguished and dried in the oven at 60 °C for 48 hours.

Then, the dry matter root and shoot were cooled to the room temperature, then, directly be weighing the dry matter in the scale.

### *Experimental design and Statistical analysis*

The experiment was randomized block design with three replications. The plant's species, waterlogging and control treatments were randomly arranged in each group. The data were subjected to analysis the ANOVA procedure. Means for the treatments were analyzed with the least significant difference test at  $P = 0.05$ . The R Studio was used to analyze the statistical data.

## RESULTS AND DISCUSSIONS

The results of experiment support the hypothesis that cereals plant and oilseeds plant show the negative impact on plant growth under water logging condition compares to legume plant. Barley, canola



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and corn response in negative condition under the waterlogging condition compared to control (un-waterlogging), however, the legume plant (faba bean) shows the positive response under waterlogging. Cereals plant and oilseeds plant that was grown in this experiment responses in negative ways under waterlogging compare to legume plant.

waterlogging conditions. The analysis of variance ( $\alpha=0.05$ ) shows there was no significantly different between plant species and waterlogging treatment in the weight of fresh root. There was a significantly different between plants species and waterlogging treatment in weight of dry root, fresh shoot and dry shoot.

The response of plant height under waterlogging treatment shows the difference pattern between cereal plant, oil seed plant and legume plant (Figure 2.). Barley, canola and corn provide a negative response to waterlogging treatment compare to un-waterlogging treatment. The height of barley, canola and corn under waterlogging is less than their height under un-waterlogging treatment, in contrast, faba bean height shows the different response. The faba bean as a legume plantation shows the higher plant under waterlogging conditions.

The response of biomass under plant species was different under waterlogging treatment (Figure 1.). Plant biomass parameters (shoot fresh, shoot dry, root fresh and root dry) under barley, corn and canola plants shows a decreases under waterlogging treatment. In contrast, faba bean shows the increase parameters under

Crop plants (barley, corn), oilseeds plant (canola) height, and biomass were inhibited under waterlogging conditions. The duration and intensity of waterlogging condition affected on plant growth. The waterlogging treatment was applicated on the 20 days after showing under tillering stages, its application in the early plant growth will delay the growing period and it also contributes to yield losses especially in the wet years (Moore, 2001). Waterlogging constraints to barley, corn and canola in response to plant growth. The capacity of nutrient supply by root is decreasing during the waterlogged. Gas exchange in the soil was severely inhibited, packed of carbon dioxide, directly change from aerobic to anaerobic metabolism process in the root zone (Teakle, Real, & Colmer, 2006). Moreover, the anaerobe condition also affects on the unavailability of nutrients (Pezeshki, 2001).

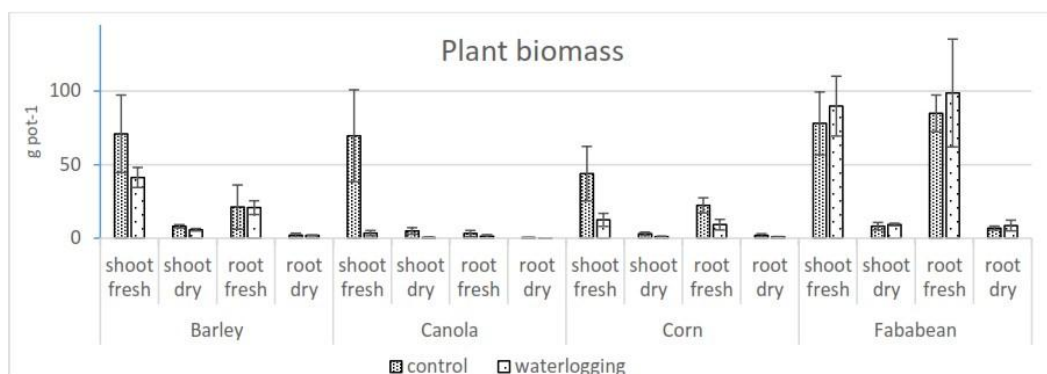


Figure 1. The mean of fresh and dry plant biomass

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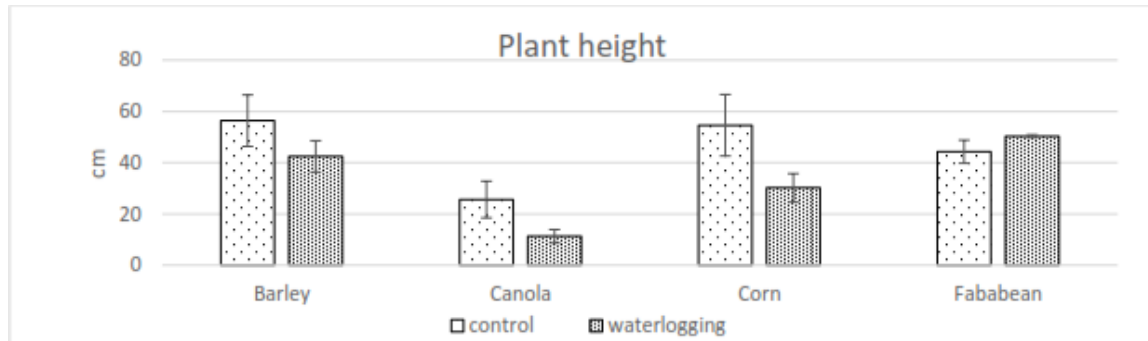


Figure 2. The mean of plant height

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There is some mechanism in plants adaptation under the waterlogging condition: shallow rooting, nodal roots, aerenchyma, alcoholic fermentation and plant nutrition (Moore, 2001). Faba bean has a tolerance under the waterlogging condition. The weight of faba bean root is equal to the weight of shoot. The amount of total root on faba bean contributes to water logging tolerance. This condition helps the plant to adapt to the flooded condition. Faba bean tolerance on waterlogging results from the ability to manage and maintain the metabolism process of photosynthesis and conductance of stomatal during the waterlogging period, another ability is to avoid the oxygen unavailability in the root zone (Caudle & Maricle, 2012).

Plant and nutrient management with the combination on waterlogging tolerant varieties, appropriate in time and rate of fertilizer be expected on decreasing plant growth response and minimising yield losses under waterlogging conditions.

Waterlogging treatment inhibited the barley growth and biomass. These results show the similarity with the article “Barley responses to combined waterlogging and salinity stress: separating effects of oxygen deprivation and elemental toxicity” by Zeng, et al (2013). The waterlogging condition decreased the plant biomass, chlorophyll and water content in barley (Zeng et al; 2013). Our research shows that barley plant height and also the weight of biomass was inhibited under waterlogging compare to the un-waterlogging condition. In addition, Zeng, et al (2013) says that the inhibition of barley growth also came from the toxicity under waterlogging in the soil.

Growth and biomass of canola inhibited under waterlogging. These results show the same statement with the journal title “Alleviation of waterlogging damage by foliar application of nitrogen compounds and tricyclazole in canola” by Habibzadeh, et al (2013). Waterlogging caused the restriction of growth, reducing the dry weight of shoot and root in canola, that condition

was triggered by the production of lipid peroxide and ethylene in the canola leaves during waterlogging (Habibzadeh et al; 2013).

Corn growth and biomass responses in the negative ways under the waterlogging condition. The similarity with the journal “Experimental Study on Water Production Function for Waterlogging Stress on Corn” by Kuang, et al (2012). The corn height was inhibited by the waterlogging condition, then it will decrease the corn yield (Kuang et al; 2012).

The tolerance plant under waterlogging was showed on the faba bean plant. The height and biomass were not affected by waterlogging condition. Similarly with the journal “Effects of flooding on photosynthesis, chlorophyll fluorescence, and oxygen stress in plants of varying flooding tolerance” by Caudle and Miracle (20012). Faba bean tolerance on waterlogging results from the ability to manage and maintain the metabolism process of photosynthesis and conductance of stomatal during the waterlogging period, another ability is to avoid the oxygen un-availability in the root zone (Caudle & Maricle, 2012).

## CONCLUSION

Waterlogging as a constraint in agriculture because inhibit the plant growth and contributes on decreasing yield. Plant shows the different response under waterlogging conditions. Barley, corn and canola are sensitive to the waterlogging condition. However, the faba bean as a legume plant tolerant to the waterlogging condition. The insensitivity of plant on the waterlogging conditions depends on the characteristics of plant mechanism to adapt with the waterlogging. Faba bean plant with the huge amount of root number and distribution zone could avoid the oxygen shortage in the root zone during waterlogging.

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